Individual and Contextual Determinants of Subjective Cognitive Fatigue

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INDIVIDUAL AND CONTEXTUAL DETERMINANTS OF SUBJECTIVE COGNITIVE FATIGUE

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To Edward Michael Posnock,
who always believed in me

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SUMMARY

Cognitive fatigue refers to the decline in mental efficiency and accompanying feelings of strain and weariness that occur over time-on-task. This study extends previous research on the determinants of cognitive fatigue by evaluating the independent and joint effects of individual differences in extraversion and performance context (individual vs. team) on reports of fatigue. Using a within-subjects counterbalanced design, 92 undergraduate participants performed a three-hour series of problem-solving tasks alone and as part of a four-person team. Results indicated main effects for context, such that all participants report greater fatigue in the solitary performance context compared to the team context. Extraversion was also negatively related to fatigue across time-on-task. However, no extraversion X context interaction effect was observed. I conclude that task engagement provides a specific source of variance in fatigue-reduction, and suggest that extraverts benefit more from task-related arousal or state positive affect.

CHAPTER 1

INTRODUCTION

The determinants and mechanisms of fatigue have been of general interest to psychological researchers for over a century (for a review, see Ackerman, 2011). Initial scientific interest in fatigue began with attempts to optimize learning in schoolchildren by adjusting the length of the school day (Thorndike, 1900). Since then, focus has shifted from cognitive tasks to production output during industrialization, to pilot performance during World War II, to driver safety in the post-war period (Cameron, 1973). Currently, research focus has returned to fatigue outcomes in cognitively-challenging tasks in work and education (Okagbaa, Shell, & Filipusic, 1994), as the U.S. labor force turns increasingly from manufacturing to white-collar jobs requiring mental work (U.S. Bureau of Labor Statistics, 1992). Recent studies show the impact of fatigue in a variety of settings, including college admission testing (Ackerman & Kanfer, 2009), driving (Rydstedt, Johansson, & Evans, 1998), and occupational health and safety (Baker, Olson, & Morrisseau, 1994). Hancock and Desmond (2001) further suggested that nearly 22% of aircraft safety failures involve fatigue as a contributing factor. Fatigue has also been shown to spill over into leisure and family time (Rydstedt, Johansson, & Evans, 1998), and Demerouti, Bakker, Nachreiner, and Ebbinghaus (2002) list mental fatigue as a key precursor to burnout.

Despite the putative negative influence of fatigue on sustained performance on tasks that demand high levels of attention (Davis, 1946), and the ubiquity of reports of fatigue among workers (Ahsberg, Gamberale, & Kjellberg, 1997), researchers have had

great difficulty providing an adequate definition of fatigue. Early definitional problems focused on disagreements over what actually constituted fatigue. Martyn (1913), for example, proposed that fatigue reflected a depletion of mental resources that was best operationalized in terms of a gradual decrease in work output. Others, such as Muscio (1921), argued that fatigue pertains to the experience of fatigue itself. Dodge (1917) offered a third view, arguing that feelings of fatigue, "may, after all, turn out to be subjective indicators of real fatigue," (p.110). Modern conceptualizations of fatigue continue to differ as a function of research objectives, but there is widespread agreement that fatigue may be broadly defined as "a generalized response to stress over a period of time, with effects which may be either acute or chronic, or both, confined to the subjective state of the individual or extending into measurable aspects of his performance," (Cameron, 1973, p. 640).

Investigations into the determinants of fatigue across a range of different psychology subdisciplines may be broadly organized into three inter-related groups: (1) person determinants, (2) situational influences, and (3) measurement issues. Although findings provide evidence for the role of a variety of person and situation determinants, few studies have examined the interactive effects of person and situation on fatigue in a cognitively-demanding task performed over time. The purpose of the present study is to investigate the person-situation interaction effects on subjective cognitive fatigue over time-on-task.

Defining fatigue

Cognitive fatigue refers to the motivational/affective, behavioral, and experiential consequences that result from sustained mental work (Åhsberg, 1998; Christodoulou,

2005; Grandjean, 1968). According to Grandjean (1968), "the state of [cognitive] fatigue is accompanied by a decrease in motivation to work, a decrease in physical and mental performances, and by the occurrence of subjective feelings of fatigue," (p. 436).

Researchers have tended to employ one of two related conceptualizations of cognitive fatigue (Wendt & Palmerton, 1976). Among early industrial researchers, the objective fatigue or performance decrement model (Kinsman & Weiser, 1976) represents the most well-known and widely-used conceptualization. This approach defines cognitive fatigue as "time-related deterioration in the ability to perform certain mental tasks," (DeLuca, 2005, p.38), in which fatigue is operationally defined as the observed decline in performance over time-on-task. Research from this perspective assumes that mental efficiency degrades over time-on-task. Once the effects of practice have been isolated, the resulting performance decrement is assumed to be a direct reflection of fatigue-related mental decline (Ash, 1914).

A second conceptualization of fatigue focuses on the experiential effects of fatigue over time-on-task (Christodoulou, 2005). Studies using this paradigm typically examine changes in subjective (cognitive) fatigue, experiential fatigue, or feeling tone over time-on-task (Ackerman, 2011). In this perspective, self-reports of fatigue refer to subjective fatigue, while observations of performance decrements over time are considered indices of objective fatigue. A number of researchers have noted, however, that attributing performance decrements to fatigue is inherently problematic (e.g., Noll, 1932; Bartley & Chute, 1947). For example, Noll (1932) observed that motivation and effort moderate the relationship between cognitive fatigue and performance decrement, stating that "the chief weakness of […] measurement of fatigue lies in the fact that it is

very difficult to determine whether a measured decrease in efficiency is due to actual fatigue or loss of interest," (1932, p.175). Muscio (1921b) also noted that subjective fatigue may confound the study of the expression of fatigue-related performance decrements, stating that "Any fall in normal industrial output curves may be very largely due […] to the painful feeling-tone of 'fatigue' feelings," (1921b, p.135). In contrast, measurements of subjective fatigue require no attribution regarding the source of behavioral variance.

The Subjective Fatigue-Performance Relationship

The most consistent finding in fatigue research is that feelings of fatigue increase steadily over time-on-task (e.g., Boksem, Meijman, & Lorist, 2006; Kaneko & Sakamoto, 2001). However, evidence on the relationship between the subjective component of fatigue and objective measures of performance over time-on-task have been inconsistent. Several studies provide evidence to support the notion that subjective fatigue serves as a correlate or expression of a decline in mental efficiency and performance (Arai, 1920; Lorist, Klien, Nieuwenhuis, De Jong, Mulder, & Meijman, 2000). For example, Arai (1920) found a significant relationship between introspective reports of fatigue feelings (from "Good" to "Tired") and accuracy on a continuous multiplication task (r = -.31). In one of the few studies that assessed both subjective and objective fatigue, Lorist et al. (2000) found opposing trajectories for feelings of fatigue and reaction task times, though no statistical comparison was reported.

Nonetheless, studies involving less than six hours time-on-task (e.g., Ahsberg et al., 2000; D'Huyvetter, 1987; Wolf, 1967) have often failed to find significant correlations between feelings of fatigue and performance. For example, Poffenberger

(1928) measured performance and feeling-tone ratings repeatedly over the course of four experimental tasks. Participants performed continuous addition, sentence completion, judging compositions, and an intelligence test over a five and one half-hour period. Poffenberger found that subjective fatigue increased relatively steadily over time for all tasks, but performance increased over time on the intelligence test, decreased over time for the addition task, and varied upward and downward in a saw-tooth pattern for the completion and composition tasks. These data suggest that subjective fatigue may not operate as a simple correlate of performance decrement.

Dodge (1917) directly addressed the lack of association between feelings of subjective fatigue and objective performance over time- on-task. Specifically, he proposed that feelings of subjective fatigue serve as a protective mechanism that precede and prevent physical harm to the organism, in the same way that hunger or thirst function to direct behavior in order to prevent physical decline. According to Dodge (1917), the experience of subjective fatigue encourages the individual to stop work, and so prevents further depletion of critical resources. In this view, Dodge (1917) argued that feelings of fatigue serve to prevent exhaustion, rather than to simply reflect exhaustion.

If feelings of fatigue signal the individual to stop work, then subjective fatigue should predict disengagement from a task. Nilsson, Nelson and Carlson (1997) found support for this notion in a study of driving behavior. Nilsson et al. (1997) examined the relationship between time-on-task and subjective fatigue. Participants were instructed to drive as long as possible, up to 240 minutes, in a driving simulator. Fatigue self-reports were taken every twenty minutes, and the total time each participant spent in the simulator was recorded at the point when each participant withdrew from the task.

Nilsson et al. (1997) found that although drivers showed widely varying rates of fatigue over time-on-task, participants reported similar levels of subjective fatigue at the point at which they withdrew from the experiment. Nilsson et al. (1997) divided drivers into ten groups based upon how long they had driven, from 40 to 240 minutes, and found that the rate of fatigue increase was steeper for those who had spent less time-on-task. An important conclusion from these findings is that although reported fatigue may not predict performance decrement, a degree of subjective fatigue may be inferred from objective measures. Furthermore, individual differences in vulnerability to fatigue may obscure the relationship between subjective fatigue and task withdrawal.

Ackerman and Kanfer (2009) examined the relationship between fatigue and performance using three forms of the SAT exam: a long (4.75 hr.), standard (3.75 hr.) and short (2.75 hr.) version. Subjective fatigue assessments were conducted every fifty minutes time-on-task. They found that while average subjective fatigue ratings increased steadily across time-on-task for all conditions, performance remained relatively stable. Indeed, in the long test condition, performance increased significantly more than in the standard test length condition, and performance in the final 50-minutes of the session, when fatigue was expected to be at its highest, was significantly higher for the long testing condition compared with the standard length.

In summary, recent studies suggest that subjective fatigue is not merely an affective manifestation of declining mental efficiency. Rather, feelings of fatigue appear to serve as an early-warning indicator of resource depletion. From this perspective, subjective fatigue is not merely an outcome associated with mental work, but rather represents a crucial element in the effort-regulation system as a whole. In line with these

findings, Kanfer (2011) has further suggested that individual differences in motivational traits and mechanisms are likely to mediate the relationship between subjective fatigue and performance.

Resource Allocation Models of Fatigue

Modern approaches to understanding the determinants and consequences of subjective fatigue build upon Kahneman's (1973) resource model of attention. According to Kahneman (1973), individuals maintain a finite pool of cognitive resources that can be allocated to different tasks during a given moment and across time. The expenditure of resources on target task performance creates a decline in the pool of available resources. *Ceteris paribus* (all other things equal), in tasks that demand sustained attentional effort, a decline in the pool of cognitive resources due to task demands has a negative effect on task performance (Kahneman, 1973).

Kahneman's model views arousal as a source of reserve capacity. According to Kahneman (1973), arousal is determined by task demands and endogenous factors, such as motivation and wakefulness. While there are physical limitations to the division of attention, Kahneman (1973) proposes that resource allocation and reallocation of available resources to different tasks occurs through a feedback loop mechanism. As attention and effort are directed toward a task, demands on capacity are evaluated, leading to a "surge of arousal to meet increased demand," potentially causing "interruption of other activities," (Kahneman, 1973, p. 150). Thus, allocation of effort leads to an increase in the availability of resources in general with a corresponding relative reduction in resources available for secondary tasks. While Kahneman's model

does not include fatigue, it does incorporate relevant components such as effort, attention, and the concept of "resources," providing a framework for future fatigue models.

Ackerman and Kanfer's (2011) "circuit" model of fatigue and Hockey's (1993) compensatory control model extend Kahneman's (1973) model to the study of cognitive fatigue over time. The Ackerman and Kanfer (2011) and Hockey (1994) models share several basic assumptions. First, both models posit that increasing arousal levels provide a buffer from subjective fatigue by increasing the amount of resources available to the individual. In other words, both models predict that subjective fatigue is less likely to be experienced in a high, compared to low state, of arousal. Second, both models propose that an individual's motivation plays a key role in predicting the experience of subjective fatigue and its relationship to performance. Finally, both models incorporate off-task thoughts and behaviors as threats to the pool of resources available for task effort.

The chief difference between the models is in the abstract representation of fatigue itself. In Ackerman and Kanfer's (2011) model, fatigue indicates resource depletion, while Hockey (2011) suggests that fatigue indicates an increase in some quantity (specifically, resistance to re-activation of goal states). Regardless of what subjective fatigue signals, however, both models predict: (1) an increase in subjective fatigue over time spent on unpleasant or externally-imposed tasks (2) that cognitive resources budgeted to a task can be increased as a function of motivation, and (3) that total cognitive efficiency can be increased by rest or increased arousal.

Arousal, Extroversion, and Subjective Fatigue

There is substantial evidence for the impact of arousal on performance (Caldwell, 2001; Haskell, Kennedy, Wesnes, & Scholey, 2005) and the relationship between arousal

and extraversion (Beauducel, Brocke, & Leue, 2005; Brocke, Tasche, & Beauducel, 1997). Resource-based models of fatigue also propose that arousal level plays a key role in feelings of fatigue, with recent findings by Maridakis, Herrin, and O'Connor (2009) showing an inverse relationship between level of arousal and feelings of fatigue. From a trait perspective, changes in arousal and associated feelings of fatigue during sustained task performance may also be impacted by relatively stable individual differences in extraversion/introversion.

Since Tupes and Christal (1961) first identified the personality factor of surgency, researchers have made substantial progress identifying the biopsychological subprocesses that form the behavioral system now known as extraversion (E.g., Boksem, Meijman, & Lorist, 2005; Lindin, Zurron, & Diaz, 2007). Research by Eysenck (1967) and others (e.g., Matthews, Davies, & Lees, 1990; Matthews & Gilliland, 1997) provides support for the notion that introverts maintain higher baseline levels of arousal than extraverts, and that extraverts often seek to raise baseline levels of arousal through environmental stimulation.

Extraversion, characterized by lower levels of baseline arousal, has been studied in relation to fatigue, especially in relation to task demands. Much of the prior research on extraversion-related differences in fatigue has utilized monotonous or attentionally-demanding task paradigms such as vigilance or choice reaction-time tasks (e.g., Beauducel, Brocke, & Leue, 2006; Schmidt, Beauducel, Brocke, & Strobel, 2004). Vigilance tasks require participants to passively monitor a display for a low-frequency signal embedded in "noise," and are characterized by constant demands on attention and lack of stimulation (Parasuruman & Davies, 1976). Reaction time tasks similarly require

sustained attention, in addition to working memory demands and a higher base rate of responding (Schmidt et al., 2004). Both task types are associated with declining arousal levels over time-on-task (e.g., Schmidt et al., 2004; Hulst, Meijman, & Rothengatter, 2001). These tasks are frequently used to test Eysenck's (1967) baseline arousal hypothesis as they are expected to produce greater arousal decrements (and by extension, increases in fatigue) for extraverts (E.g., Smillie, Yeo, & Lang, 2009; Smulders & Meijer, 2007). Verwey and Zaidel (2000) found extraversion predicted drowsiness in a monotonous driving simulation (r = .28), and that Extraversion was correlated with subjective evaluation of fatigue-related performance (r = .47). Matthews and Desmond (1998), however, found no significant relationship between Extraversion and pre- or post-task subjective fatigue scores on a combined driving-simulation/conditional reaction time task.

The pattern of introvert-extravert differences in fatigue observed on vigilance tasks reflects specific, unique task demands. Different task demands and environmental constraints have yielded opposing results. For example, DeVries and Van Heck (2002) surveyed Swedish workers and found that extraversion was negatively associated with occupational subjective fatigue. Complex tasks performed in the laboratory have not shown differences between introverts and extraverts; in a study of subjective fatigue and performance differences in achievement testing, Ackerman and Kanfer (2009) did not observe a relationship between extraversion and experiential or objective fatigue measures. Thus, although time-on-task is typically the strongest predictor of subjective fatigue, task demands play a crucial role in determining extraversion's influence on the experience of fatigue.

The effects of extraversion on task performance over time have also received considerable research attention. Smulders and Meijer (2008) compared introverts and extroverts on a vigilance task and found that among the poor performers, those higher in extraversion showed further performance decline while those low in extraversion improved across trials. Similar findings were obtained by Geen (1984), who examined mean levels of auditory stimulation preferred by participants high and low in extraversion while conducting a learning task. When the low-extraversion group was exposed to the level preferred by the high-extraversion group, they experienced significant performance decrements ($d = 2.92$). Geen concluded that introverts had been "over-aroused" by this stimulation. However, Geen failed to find "under-arousal" effects in the high-extraversion group as a result of sub-optimal stimulation.

Brocke, Tasche, and Beauducel (1997) proposed an alternative explanation for extraversion-arousal differences, suggesting that differences in performance were not due to baseline arousal differences but rather differential reactivity of arousal to stimulation. Brocke et al. (1997) examined the biopsychological foundations of extraversion by comparing introverts and extraverts on a vigilance task across three different levels of stimulus intensity. They compared arousal (EEG alpha waves) and effort (ERP P300 amplitude) between extraverts and introverts at several points during the study and with varying levels of background noise. Although no significant performance effects were observed, they found compensatory effort levels under sub-optimal levels of arousal. Extraverts registered lower levels of effort as stimulation increased, while introverts displayed the classic curvilinear trend, where compensatory effort was high under low stimulation, low under moderate stimulation, and high again under high stimulation.

A second study by Beauducel, Brocke, and Leue (2006) revisited extraversion and physiological arousal, this time comparing introverts and extraverts on a choice-reaction time task selected for its monotony. Physiological indicators of effort and arousal showed similar patterns across levels of extraversion as found by Brocke et al. (1997). With a less-stimulating task, Beauducel et al. (2006) found significant performance decrements among extraverts over time in concert with decreasing arousal and increasing effort, while introverts' performance and indicators stayed relatively stable. Taken together, these studies suggest that individual differences in extraversion influence the optimal level of stimulation under certain conditions. While these studies assessed performance, their results concerning arousal overlap conceptually with subjective fatigue research, reflecting a common hypothesized component in both behavioral and subjective processes. Comparing the relative stimulatory impact of task demands and environmental context remains a challenge, and debate over the reactivity versus baseline arousal hypotheses continues (Matthews, 2011).

Context and Fatigue

A perusal of findings on the influence of extraversion on feelings of fatigue and performance over time-on-task suggests that the context in which activity takes place may play a critical role in arousal regulation. Although most time-on-task studies examine cognitive fatigue and performance in the context of performing an experimenter-paced individual task (such as a reaction time task), several studies suggest that the broader context in which tasks are performed may also influence feelings of fatigue over time-on-task. Hockey and Earle (2006) examined the context effects of workplace control on subjective fatigue. The task was a yoked simulation of office work in which

one participant, controlling the pace of office work, was yoked to a second participant, forced to follow the pace of work dictated by the first. They found that participants doing mock office work reported less fatigue when they had control over their work schedule relative to when they had no control. Similarly, Nelson, Nilsson, and Johnson (1984) showed that the environmental conditions under which a task is performed influenced fatigue ratings. Participants reported feeling more fatigued after time-on-task in a warm room, than after time-on-task in a cool one.

One contextual feature that has received increasing attention pertains to whether the task is conducted alone or with others. Whitmore, Chaiken, Fischer, Harrison, and Harrison (2008) compared fatigue effects in a team and individual context. Sleep-deprived Air Force trainees participated in a 36-hour simulated command and control exercise individually and as part of a three-person team. While subjective fatigue was not assessed, performance showed a clear drop-off over time in the individual context, while performance in the team context remained relatively steady. Whitmore et al. (2008) inferred that the team context was more arousing and that this reduced fatigue effects on performance over the course of the exercise. They also suggested that the team format incorporated an element of accountability, which increased motivation to maintain performance in the face of fatigue.

Given the increasing use of teams in work settings (Barry & Stewart, 1997), the influence of this contextual factor on fatigue and performance is of particular importance. In addition, both scientists and practitioners have raised increasing concern about identifying the person traits that impact team performance (de Jong, Bouhuys, & Barnhoom, 1999). To date, however, relatively little is known about the interaction

between personality and context in determining subjective fatigue. Only one study has been reported examining the influence of extraversion on subjective fatigue across complex task contexts (Belojevic, Slepcevic, & Jakovljavic, 2001). Belojevic et al. (2001) hypothesized that extraverts and introverts would be differentially affected by noise levels due to differences in resting arousal. Study participants performed a multiplication task in a quiet room or in a room with pre-recorded traffic noise being played over a loudspeaker. Belojevic et al. (2001) found that extraverts performed the task more quickly in the noisy condition than the quiet condition. However, high-extraversion participants showed no significant difference in feelings of subjective fatigue. Introverts performed equally well in the noisy and quiet contexts, but reported higher levels of fatigue in the noisy condition than the quiet one. These findings suggest that context effects on the individual's state may depend on inferred arousal levels conditioned by relatively stable individual differences in extraversion.

The present study extends research on the extraversion-fatigue relationship by examining the independent and joint impact of person and performance context variables on motivational state and cognitive fatigue over time-on-task. Consistent with prior research on the effects of extraversion on fatigue in solitary performance contexts, I hypothesize the following between-subjects effect:

H1: Extraversion will be significantly positively related to post-task subjective fatigue in the individual performance context (anticipated $f^2 = .2$).

In contrast to the individual performance context, however, performance in the team context typically demands social interactions that are assumed to sustain higher levels of arousal. Because arousal levels eventually decline with time-on-task

(Beauducel et al., 2006), the team context is expected to mitigate the fatigue effects associated with declines in arousal over time-on-task, particularly for people high in extraversion. Thus, I hypothesize the following between-subject effect:

H2: Extraversion will be significantly negatively related to post-task subjective fatigue in the team performance context (anticipated $f^2 = .3$).

Consistent with resource-based process models of fatigue, increasing subjective fatigue and increasing task aversion over time-on-task are expected to serve an informational function in averting cognitive depletion. However, the trajectory of subjective fatigue increases is influenced by both the context and individual differences. That is, individual differences in extraversion and context are hypothesized to interact in their effect on intra-individual change in fatigue ratings across time-on task. Thus, I hypothesize the following within-subject effects:

H3: There will be a main effect of time-on-task, such that all participants will report monotonically increasing levels of fatigue over time-on-task in all performance environments.

H4: There will be a main effect of context, such that on average, participants will report greater increases in fatigue over time-on-task in the individual context than in the team context.

H5: Individual differences in extraversion will be significantly related to the trajectory of subjective fatigue ratings during each performance session, such that persons higher in extraversion will report a significantly smaller increase in subjective fatigue over time-on-task in the team context than in the individual performance context.

Persons lower in extraversion will report smaller increases in fatigue over time-on-task in the solitary task relative to the team task.

I also explore motivational attributes that may also affect post-task fatigue ratings, beyond that of extraversion. Specifically, I examine the relationship between preferences for environmental stimulation and peer-interaction on post-task fatigue. I hypothesize that:

H6: In the individual context, higher scores on factors relating to preference for environmental stimulation and peer-interaction will predict higher levels of post-task fatigue, (anticipated $f^2 = .08$).

H7: In the team context, higher scores on factors relating to preference for environmental stimulation and peer-interaction will predict lower levels of post-task fatigue, (anticipated $f^2 = .1$).

Although the main focus of this research is on person and contextual determinants of subjective fatigue, I conduct exploratory analysis on the role of motivational traits and subjective fatigue on performance. Building on the resource-based fatigue models, I hypothesize that:

H8: An approach motivation X subjective fatigue interaction on performance in both the individual and team performance context (anticipated $f^2 = .10$), with individuals who are higher in approach motivation and lower subjective fatigue achieving the highest level of performance.

The hypotheses for this study encompass three primary components: Person factors, task demands, and environmental factors. Testing these factors simultaneously required improving upon methods utilized in previous studies of fatigue. Previous studies

have often artificially dichotomized extraversion, utilizing mean or median-split designs to compare "introverts" and "extraverts" (e.g., Belojevic et al., 2001). For this study, extraversion was assessed as a continuous covariate. Previous fatigue research has made frequent use of vigilance or reaction-time tasks with extremely specific task demands (namely, sustained attention), and little task-related stimulation. The results of such studies, as they relate to extraversion, do not generalize to situations with more complex task demands. In order for the study to have applied value, the task paradigm needed to be complex (i.e., with multiple demands on memory, reasoning, and effort). Additionally, assessing the effects of performance context (i.e., team vs. individual) on subjective fatigue required a task that could be performed individually or as a group without significantly altering task demands.

A series of *a priori* power analyses at the level of $\alpha = .05$ indicated that to achieve a power of .90, the number of participants ranged between 54 ($f^2 = .25$ and 109 ($f^2 = .12$). The study design was multilevel, with multiple measurement occasions nested with individuals. *A priori* power and effect size analysis for multilevel models is still an emerging area of research (see Scherbaum, 2009, for a discussion), but Kreft (1996) suggests 90 clusters are necessary to observe cross-level interactions.

CHAPTER 2

METHODS

Participants

92 participants were recruited from undergraduate students enrolled in psychology courses in a southeastern university. Participants volunteered for the study in exchange for course credit. Following the results of the power analyses, 92 participants were deemed sufficient for the study, providing 92 clusters at Level-3 (Individual), 184 observations at Level-2 (Context), and 736 observations at Level-1 (Measurement occasion). Participants' ages ranged from 18 to 25, except for one participant who listed his age as "> 25". Eighty-five percent of participants were between the ages of 18 and 20. The sample was 55% male, 45% female. Participants reported majors in 15 areas, with the largest concentrations in Industrial Design (19%), Earth Science (14%), Biology (12%), and History, Technology, and Society (12%). Participants had normal or corrected-to-normal hearing, vision, and motor coordination, and were literate and fluent in English.

Materials

The stimulus materials used in the session to elicit fatigue were eighteen financial planning word problems. The financial word problems task was chosen to provide a cognitively-demanding task that could be administered in both individual and small group settings. Each financial word problem required the individual or group to perform several calculations and to make judgments about the best course of action. The set of financial planning word problems administered are presented in Appendix C.

The financial word problems used in this study were in part adapted from ten problems developed by Ackerman and Beier (2006) for a study investigating the determinants of adult domain learning. Eight additional word problems were created to

augment the original set of ten in order to create a sufficient number of stimuli for both sessions. In the Ackerman and Beier (2006) study, participants were instructed to focus on concepts. In this study, however, participants were instructed to focus on making the mathematical calculations and using their judgment in order to arrive at the best solution.

Each financial word problem could have more than one correct answer, depending on the way that the individual and/or team framed the problem, and the judgments made. The problems were set at a moderate level of difficulty such that solutions demanded some domain knowledge, but correct answers could be obtained by persons without formal finance or accounting training. Solving the problems adequately required application of basic arithmetic of moderate difficulty and application of problem-solving skills. Arithmetic and problem-solving (such as that found on an intelligence test) have both been shown to be fatiguing (Poffenberger, 1928).

Procedure

Individuals who volunteered to participate in the experiment received an online consent form and attached online take-home questionnaire (THQ), designed to obtain demographic and biographical data related to academic plans, study habits, and to assess individual differences in behavioral preferences and personality/motivational traits. Additional measures not directly related to the hypotheses were taken but are not reported. Following completion of the consent form and THQ, participants were scheduled for two task performance sessions, each three hours in length. The length of each session was based on prior research suggesting that reports of fatigue in cognitively-demanding tasks often only emerge after an hour or more of time-on-task (see, e.g.,

Ackerman, 2011; Hockey & Earle, 2006). Laboratory performance sessions were scheduled a minimum of two days apart.

In each session, participants completed a series of financial planning word problems for a period of three hours. In one session, participants were instructed to complete the problems on their own. In the other session, participants completed the problems as part of a four-person team. To control for order effects, performance context (i.e., team / individual) was counterbalanced. Due to the logistical difficulty of scheduling team performance sessions, only partial counterbalancing was accomplished. 59 participants completed the individual context first (Order A), and 33 completed the team context first (Order B). However, comparisons between the two orders did not show differences on the criterion measure (Individual: F (1, 91) = .38, MSE = 156, *ns*; Team: F (1, 91) = 1.45, MSE = 94.73, *ns*).

Individual Performance Condition

Participants in the individual performance condition were seated at individual work stations in a large room upon arrival at the session. Prior to starting the task, all participants were administered a brief questionnaire designed to assess current (state) feelings of fatigue, affect, and task motivation. After completing the questionnaire, the experimenter distributed a financial planning packet that contained both the instructions and the task problems to be completed during the session.

Participants were instructed to take the instructions from the packet, and the experimenter read the instructions aloud to the participants. A copy of the instructions is provided in Appendix A. After providing instructions, the experimenter instructed

participants to begin Problem 1. Participants were instructed to work at their own pace toward completion of the nine problems provided in their packet.

After forty-four minutes time-on-task, participants were instructed to put down their paper and pencils. Participants completed paper-pencil measures to assess fatigue and task motivation, and were given a five-minute break. Participants then resumed the task for another forty-four minutes, at which point they were stopped for a third assessment and a five minute break. Participants then resumed the task for the last forty-four minute performance period. Upon completion of the final forty-four minute leg of the 132-minute session, participants completed a final assessment of fatigue.

Team Performance Condition

Teams were comprised of four participants, with participants randomly assigned to teams upon arrival at the laboratory. Members of each team were seated at a single table containing a single word problem packet. Prior to beginning the task, each participant completed a questionnaire assessing fatigue, affect, and motivation, as in the individual condition. After completing the questionnaire, the experimenter provided the team with instructions for performing the task. In contrast to the instructions provided to participants in the individual context, instructions to the team informed members that they were to work together to solve each problem. In all other respects, the task performance instructions in the team context were identical to that provided in the individual context. A copy of the instructions provided to the team appears in Appendix B.

Each team worked on financial word problems continuously for 132 minutes over the course of the session, pausing at forty-four minute intervals for assessments and

breaks with the same schedule as used for participants in the individual performance condition. Teams worked at their own pace through the problem set, and completed a final questionnaire at the end of the last performance period.

Measures

Take Home Questionnaire (THQ) Behavioral Measures

Participants completed an online questionnaire to assess the following biographical information, study behavior, and personality traits prior to their first performance session.

Biographical information.

Participants were asked to provide their age, gender, and academic major with single item responses.

Preference for Environmental Stimulation (PES).

Individual differences in homework habits were assessed with a 7-item, locally developed scale designed to measure the extent to which the individual prefers environmental stimulation during homework sessions, and the nature of that stimulation. Items in the PES questionnaire are similar to those in Homework Preferences Questionnaire (Hong & Milgram, 1999), but focus on the individual's preference for environmental stimulation rather than the individual's study habits ($\alpha = .41$).

Preference for Peer Interaction (PPI).

Individual preferences for peer- or self-focused study were assessed with a locally-developed 7-item measure. Items assessed the extent to which participants prefer to study with others (high) or by themselves (low) when working on homework or

studying (α = .76). Ratings were made along a six-point scale from 6 (Strongly Agree) to 1 (Strongly Disagree). A sample item is "I do not like to study alone."

Motivational Traits.

A twenty-nine-item measure of motivational factors was administered from the Motivational Trait Questionnaire (MTQ; Kanfer & Ackerman, 2000). The MTQ comprises four sub-scales: Desire to Learn (8 items; α = .82), Mastery (8 items; α = .81), Other-referenced Goals (7 items; α = 0.85), and Competitiveness (6 items; α = 0.90). Items are scaled from 1 (very untrue of me) to 6 (very true of me).

Extraversion.

Goldberg's (2011) international personality inventory pool (IPIP) was used to assess extraversion. Extraversion items consisted of the ten-item domain measure of Extraversion from the Big-Five Factor Markers (α = .91). Items are measured along a six-point Likert-type scale (1=Very inaccurate, 6=Very accurate). A sample item is, "Feel comfortable around people."

Criterion Measures for Individual Context

The following measures were administered in a series of questionnaires at multiple time points during both the Individual Context and Team Context sessions to assess affective and conative state variables. A layout of measurement occasions within each session can be found in Table 1 and 2. Table 3 lists the individual measures administered at each time point. Unless otherwise specified, participants will rate their agreement with the items along a six-point scale (1=Strongly Disagree, 6=Strongly Agree).

Table 1
Layout of Individual Context Session.

Section	Time (Min)	Time Elapsed (Hr:Min)
Time 1 Measures (Pre-task)	7	0:07
Financial Planning Problems	44	0:51
Time 2 Measures	5	0:56
Break	5	1:01
Financial Planning Problems	44	1:45
Time 3 Measures	5	1:50
Break	5	1:55
Financial Planning Problems	44	2:39
Time 4 Measures (Post-task)	7	2:49

Table 2

Layout of Team Context Session

Section	Time (Min)	Time Elapsed (Hr:Min)
Time 1 Measures (Pre-task)	7	0:07
Financial Planning Problems	44	0:51
Time 2 Measures	5	0:56
Break	5	1:01
Financial Planning Problems	44	1:45
Time 3 Measures	5	1:50
Break	5	1:55
Financial Planning Problems	44	2:39
Time 4 Measures (Post-task)	7	2:49

Table 3

Measures Assessed at Each Time Point in the Performance Session

Time 1	Time 2	Time 3	Time 4
Subjective Fatigue	Subjective Fatigue	Subjective Fatigue	Subjective Fatigue
Pre-task Motivation	Effort Patterns	Effort Patterns	Effort Patterns
Pre-task Interest	Subjective Performance	Task Motivation	Subjective Performance
Pre-task Frustration	Task Load	Task Interest	Task Load
Concentration	Teammate Assessment*	Task Frustration	Subj. Measure of Ind. Contr.to Team*
		Concentration	Teammate Assessment*

* = Measures administered only during team session

Note: Subj. Measure of Ind. Contr.to Team = Subjective measure of individual's contribution to team

Subjective Fatigue.

Subjective fatigue was measured using the twelve-item Ackerman and Kanfer (2009) scale, comprising the affective, motivational, and somatic symptoms of fatigue. The original scale was constructed using items from the Positive Affectivity/Negative Affectivity Schedule (Watson, Clark & Tellegen, 1988), the Profile of Mood States (Lorr et al., 2003), and locally developed items (Individual context $\alpha = .88$; Team context $\alpha = .86$). A sample item is "I feel drained of energy." The scale was administered four times over the course of each session, for a total of eight administrations.

Task Motivation.

This seven-item scale assesses the extent to which participants are motivated to succeed on the financial planning questions based upon a brief description of the questions themselves (pre-task) and their experience with them (mid/post-task). Task motivation was assessed twice per session using all the original items from the Success Motivation dimension of the Motivation subscale of the Dundee Stress State Questionnaire (DSSQ; Mathews, Campbell, Falconer, Joyner, Huggins, Gilliland, Grier, & Warm, 2002). A sample item is "I am eager to do well." Pre-task internal consistency coefficient was .81, but Time 3 measurement had a reliability of .57. Item-total correlations indicated that one item, "Performing this task brought out my competitive drive" fit poorly with the scale. Dropping this item improved internal consistency at Time 3 to .81.

Task Interest.

Participant interest in the financial planning problems task was assessed pre-task and post-task with pre-task and post-task Intrinsic Motivation dimension of the Motivation Subscale of the Dundee Stress State Questionnaire (Matthews et al., 2002). A sample pre-

task item is, “I expect the task will be interesting.” A sample post-task item is, “The content of the task was interesting.” The scale was administered twice per session (Pre-task $\alpha = .74$; Mid/Post-task $\alpha = .80$, Pre/Post $r = .75$, ($p < .01$)).

Task Frustration.

Five anger/frustration subscale items from the Mood scale of the DSSQ were administered to participants pre-task and post-task. Participants were instructed to rate adjectives on how well they described their current mood ($\alpha = .81$). Scores were summed to measure current frustration. Adjectives were identical for pre- and post-task measures. A sample item is, “Impatient.”

Concentration.

The six-item pre- and post-task concentration subscales of the DSSQ were administered to assess the ability of participants to focus and concentrate on the task at hand. A sample pre-task item is, “My thoughts are confused and difficult to control.” A sample post-task item is, “My mind wandered a great deal.” The measures of concentration were taken twice per session (Pre-task $\alpha = .85$; mid-task $\alpha = .93$, Pre/Post $r = .61$ ($p < .01$)).

Effort Patterns.

Effort was assessed at three points during each session (Times 2, 3, and 4). Effort was measured with a single item at Time 2 and with two items at Times 3 and 4. The first item is a one-item measure from Ackerman and Kanfer (2009), assessing patterns of effort within a section. At the end of the each section of the task, participants were asked to “describe your pattern of effort on this section,” and given four response choices. An example choice is “I decreased my effort over the course of the session.” This item was

given three times per session. The second question, locally developed, asks participants, "relative to the previous section, how would you characterize your level of effort." This assesses effort across sections. One example response option is, "Committed less effort in this section." The first and second items will be administered together in the last two assessment points.

Subjective Assessment of Individual Performance.

Each participant rated his or her own performance on the task along a six-item scale. Subjective individual performance consisted of the five items comprising the Thinking Style subscale of the DSSQ (α =.94). A sample item is, "I performed proficiently on the task."

Task Load.

Participants reported their level of effort and workload on a scale from zero to ten via the six-item NASA task load index (Hart & Staveland, 1988). A sample item is, "How much mental and perceptual activity was required?"

Criterion Measures for Team Context

Participants completed parallel criterion measures during the individual and team sessions. In addition, following team task performance participants completed several measures related to team impact and involvement. Table 3 lists the individual measures, along with additional team measures, administered at each time point. Unless otherwise specified, items are rated along a six-point scale (1=Strongly Disagree, 6=Strongly Agree).

Individual Assessment of Teamwork Behavior

Teamwork Behavior was assessed with a fifteen-item self-report measure adapted from Wang et al. (2010). This scale measures team-oriented behavior along three dimensions: Cooperation (α = .89), Advocacy (α = .80), and Negotiation (α = .78). The five items from each scale that loaded most highly on their particular dimension are included. Items were reworded to reflect past tense in relation to the team task they just completed. The original measure is in the present tense. For example, "I enjoy" became "I enjoyed." A sample item is, "I shared ideas."

Peer-Report of Individual Contributions.

Each member of the team rated every other member on their contributions to the team on a five-item scale from 1 (Poor) to 5 (Excellent). These five items were adapted from a form by Scherer (1988) for teachers to evaluate students' participation in group work. A sample item is, "Helped team stay on task". The peer assessment score is the sum of the scores given for each member of the group. The original scale contains nine items, five of which were applicable to the present scenario.

Analysis

The multilevel design selected for the study compared subjective fatigue between participants within a given performance context, and within participants across contexts. The study design was within-subjects, repeated-measures, where subjective fatigue was measured over time-on-task for each participant in both performance contexts. The data had a multilevel structure with crossed grouping factors, where measurement occasions were nested within individuals, crossed with performance context. Between-subjects effects were tested using hierarchical regression, while within-subjects effects were tested using hierarchical linear modeling (HLM).

Regression Analysis

Hypotheses 1 and 2 were tested using hierarchical multiple regression. Although subjective fatigue is conceptualized as resulting from time-on-task, previous research has shown that individuals experience varying levels of residual or trait fatigue over a given timeframe (Ackerman & Kanfer, 2009). To test the between-subjects effect of extraversion on fatigue after time-on-task, state fatigue was statistically controlled for by entering pre-task subjective fatigue in Step 1 of the regression equation. After accounting for preliminary fatigue levels, extraversion was entered in Step 2. Hypotheses 6 and 7 were tested in a similar fashion except preference for environmental stimulation and peer-interaction was entered in Step 2. Hypothesis 8 was tested by regressing self-estimates of performance on achievement motivation and subjective fatigue.

Multilevel Analysis

Hierarchical linear modeling (HLM) was used to test the effects of context and extraversion over time-on-task. HLM allowed for calculation of regression slopes over multiple measurement occasions, and accounted for between-person variation in pre-task fatigue. The impact of extraversion on fatigue within and across task contexts was evaluated using a 3-level repeated-measures design, analyzed using the lme4 package (Bates, 2012) for the R software program (R Development Core Team, 2011) Measurement occasions (time-on-task) were nested within contexts, nested within and crossed between individuals. Extraversion was entered into the equation as a time-invariant Level-3 predictor. Typically, participants would be nested within contexts, but as this study utilized a within-participant design, each participant was exposed to both task contexts, allowing for estimation of cross-context interaction effects. Context was

dummy coded, such that the individual context ("0") serves as a reference group, to which the team context ("1") was compared. Participant was entered as a random intercept variable at Level-3. Four fixed effects parameters were estimated simultaneously in the model: (1) The main-effect of time-on-task, (2) the interaction of time x context, (3) extraversion x time, and (4) a three-way interaction testing the within-subjects effect of extraversion, context, and time.

CHAPTER 3

RESULTS

Extraversion and Fatigue

Descriptive results for the THQ measures are presented in Table 4. Means, standard deviations, and alpha reliabilities for affect measures taken during the laboratory sessions are provided in Table 5. Affect inter-correlations are presented in Table 6. Due to the large number of subjective measurements taken over the course of the study, the inter-correlation matrix presented in Table 6 shows aggregated values. For each participant, average scores for affect measures over time were calculated by session (team vs. individual). Pearson *r* correlations were then calculated using these values. Fatigue score inter-correlations across time, presented in Table 7, show a simplex-like pattern within each experimental session, where scores closer to each other in time are more highly correlated than those further apart.

Pre-task fatigue accounted for 37% of the variance in post-task fatigue scores in the individual session ($r = .61$, $p < .001$), and 28% of post-task fatigue in the team session ($r = .53$, $p < .001$). The rate of change in fatigue over each session is graphed in Figure 1. Plots of the individual session time points reveal a roughly linear trend, where final fatigue level is highly dependent upon starting position. In the team session, participants actually grew less fatigued after the first 44-minute interval and then began to report increasing fatigue at time three. The "boost" granted between times 1 and 2 persisted, such that participants in the team session did not return to the fatigue levels observed in the individual session, but maintained a similar slope.

Table 4

Descriptive statistics for THQ measures

Measure	#Items	M	SD	α
Financial Interest	8	22.95	8.22	.86
Financial Knowledge	6	19.18	6.28	.89
PES	7	25.00	4.39	.41
MTQ Competitiveness	6	20.98	6.60	.90
MTQ Desire to Learn	8	36.87	4.83	.82
MTQ Mastery	8	35.99	5.35	.81
MTQ Org	7	28.74	5.78	.85
Multitasking	14	42.96	10.46	.89
NEO Activity Level	10	37.11	5.81	.69
NEO Excitement-Seeking	10	39.79	8.97	.86
BFF Extraversion	10	38.57	9.62	.91
Conscientiousness	10	46.90	7.18	.81
Neuroticism	10	26.62	7.41	.82
16PF Introversion	10	32.91	6.50	.79
PPI	7	24.51	6.43	.76
Team Attitudes - Advocate	5	22.70	3.73	.74
Team Attitudes - Cooper.	5	24.93	3.04	.77
Team Attitudes - Negotiate	5	25.88	2.94	.82

Note: N = 92. PES = Preference for environmental stimulation; MTQ = Motivational trait questionnaire; NEO = Goldberg's (2011) Neuroticism, Extraversion, Openness Personality Inventory; BFF = Big Five Factors; 16PF = 16 Personality Factor scale; PPI = Preference for Peer Interaction.

Table 5

Descriptive statistics for affect measures

		Individual			Team		
Measure	#items	M	SD	α	M	SD	α
T1 Fatigue	12	27.66	9.26	.88	28.93	9.57	.86
T1 Frustration	5	6.46	2.36	.81	6.72	2.41	.83
T1 Motivation	6	24.95	4.30	.79	24.61	4.40	.75
T1 Interest	8	28.88	7.10	.86	27.78	7.20	.86
T1 Concentration	6	25.33	5.21	.85	25.40	6.19	.91
T2 Fatigue	12	30.52	10.07	.90	26.32	8.27	.88
T2 Subj. Assess. Perf.	8	29.81	7.95	.94	33.15	6.94	.91
T2 TLX	6	4.88	1.35	--	4.22	1.12	--
T2 Team Rating	15				63.62	7.96	.91
T3 Fatigue	12	33.54	11.67	.91	28.97	10.47	.91
T3 Frustration	5	8.92	4.77	.91	7.66	3.43	.89
T3 Motivation	6	23.02	4.88	.82	23.05	4.78	.80
T3 Interest	8	26.08	7.30	.81	29.07	7.70	.89
T3 Concentration	6	23.52	7.91	.93	24.90	6.58	.92
T4 Fatigue	12	37.37	12.35	.92	33.48	9.78	.93
T4 Subj. Assess. Perf.	8	29.01	8.55	.94	31.40	5.86	.91
T4 TLX	6	5.53	1.25	--	4.62	1.13	--
T4 Teamwork - Coop.	5				23.65	3.26	.81
T4 Teamwork - Advocacy	5				16.42	3.20	.77
T4 Teamwork - Negotiation	5				24.47	3.11	.81
T4 Team Rating	15				65.30	7.48	.91

Note: N = 92; Alpha reliabilities are not applicable to NASA-TLX and are not reported; TLX = Task Load Index; Subj. Assess. Of Perf. = Subjective Assessment of Performance

Table 6

Correlations for composite self-report measures (aggregated within sessions)

Individual Session	1	2	3	4	5	6	7	8	9	10	11
1. Fatigue											
2. Frustration	.61**										
3. Motivation	-.33**	-.14									
4. Interest	-.57**	-.43**	.48**								
5. Concentration	-.71**	-.52**	.43**	.62**							
6. TLX	.47**	.28**	-.08	-.24*	-.52**						
Team Session											
7. Fatigue	.61**	.42**	-.22*	-.51**	-.61**	.43**					
8. Frustration	.44**	.46**	-.10	-.40**	-.43**	.33**	.70**				
9. Motivation	-.24*	-.13	.581**	.35**	.27*	-.14	-.27**	-.34**			
10. Interest	-.54**	-.31**	.32**	.80**	.52**	-.31**	-.57**	-.53**	.52**		
11. Concentration	-.56**	-.38**	.38**	.52**	.77**	-.47**	-.66**	-.60**	.45**	.65**	
12. TLX	.44**	.21*	-.11	-.28**	-.48**	.67**	.45**	.32**	.04	-.30**	-.37**

* = $p < .05$ (two-tailed). ** = $p < .01$ (two-tailed). df = 91.

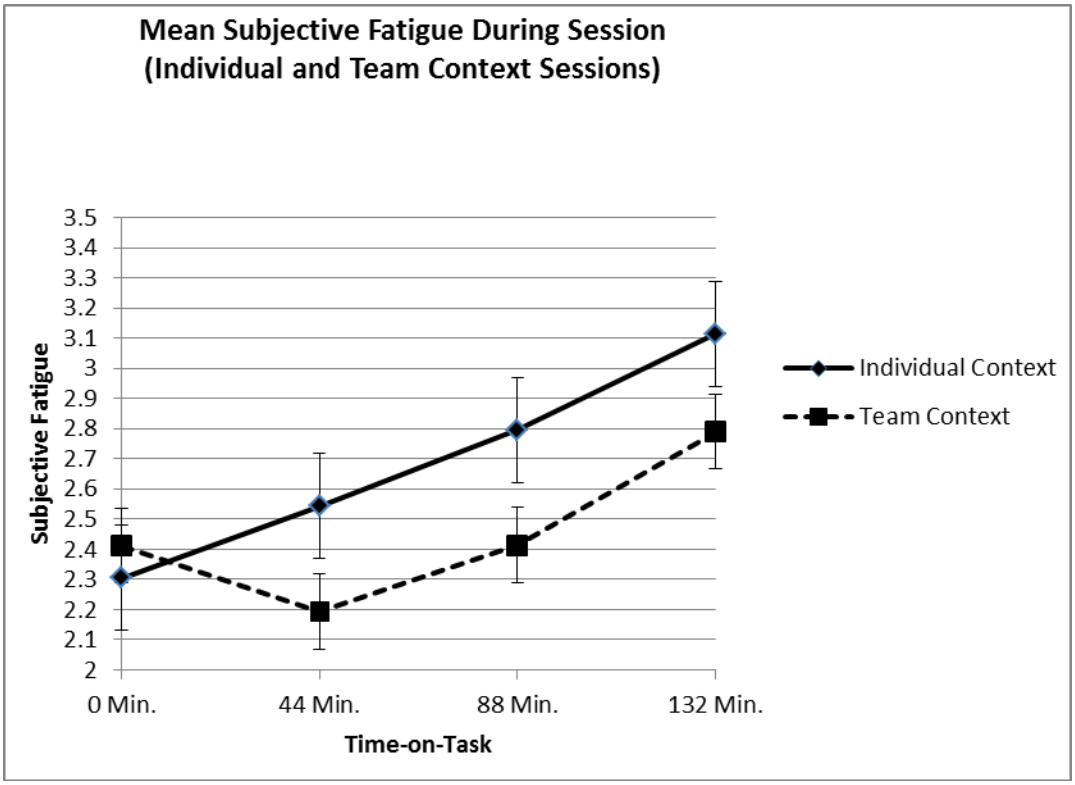
Table 7

Means, SDs, Reliabilities, and Correlations among subjective fatigue measurements across condition

	Mean	*SD*	α	1	2	3	4	5	6	7
1. Individual 1	27.66	9.24	.88							
2. Individual 2	29.81	10.18	.90	.74						
3. Individual 3	33.54	11.63	.92	.72	.83					
4. Individual 4	37.37	12.44	.92	.61	.74	.87				
5. Team 1	28.93	9.58	.90	.52	.53	.47	.41			
6. Team 2	26.32	8.27	.88	.45	.41	.47	.47	.75		
7. Team 3	28.97	10.42	.91	.36	.43	.52	.56	.60	.76	
8. Team 4	33.48	9.76	.93	.40	.45	.60	.65	.51	.67	.84

Note: All $p < .01$; N = 92; df = 91.

Figure 1



Observed fatigue effects over time-on-task in individual and team contexts

Paired t-tests showed significant differences in reported fatigue between individual and team sessions at times 2 ($t(91) = 4.11$, $p < .001$), 3 ($t(91) = 4.02$, $p < .001$), and 4 ($t(91) = 3.9$, $p < .001$). No significant differences were recorded at time 1 ($t(91) = -1.34$, *ns*). Averaged pre-task fatigue for both individual ($M = 2.31$, $SD = .77$) and team sessions ($M = 2.41$, $SD = .80$) was slightly higher than "a little bit fatigued". Participants reported on average feeling "moderately fatigued" after the individual session ($M = 3.11$, $SD = 1.03$), and between "moderately" and "a little bit" fatigued in the team session ($M = 2.79$, $SD = .81$). Extraversion was not significantly correlated with pre-task fatigue measurements in either the individual ($r = -.10$, *ns*) or the team context ($r = -.08$, *ns*), showing that subsequent analyses of extraversion's relationship to change in fatigue over time would not be conflated with starting position. The order in which participants completed the sessions did not change extraversion's relationship to pre- or post-task fatigue in either the individual (Pre: $\beta = -.61$, $p = .16$; Post: $\beta = -.23$, $p = .50$) or team sessions (Pre: $\beta = .21$, $p = .34$; Post: $\beta = -.02$, $p = .96$).

As expected and consistent with previous research, fatigue was highly, negatively related to interest in the task (Individual: $r = -.57$, $p < .01$; Team: $r = -.31$, $p < .01$) and concentration (Individual: $r = -.71$, $p < .01$; Team: $r = .-.66$, $p < .01$), suggesting that those who disliked the task more were more likely to find it fatiguing. This is consistent with Csikszentmihalyi's (1975) notion of flow states, suggesting that the difference between work and play is whether one wants to perform a task. Having goal states externally imposed requires the activation of self-regulatory resources (Hockey, 2011). The inverse of this principle predicts that those who found the task less intrinsically

pleasing had to exert greater regulatory resources toward performing it, supported by the current data. Frustration was highly, positively correlated with fatigue (Individual: r = .61, p < .01; Team: r = .7, p < .01), consistent with prior evidence (Matthews, 2011). Interestingly, motivation to perform the task was only moderately, negatively correlated with fatigue (Individual: r = -.33, p < .01; Team: r = .27, p < .05), as was the perceived load imposed by the task (Individual: r = .47, p < .01; Team: r = .45, p < .01). Thus, subjective fatigue was strongly related to affective reactions to stress, and less strongly related to motivation and workload.

Regression Results

Results of regression analyses to examine Hypotheses 1 and 2, pertaining to the influence of Extraversion on post-task fatigue in the individual and team contexts, are presented in Table 8. As shown, pre-task fatigue entered in Step 1 significantly predicted post-task fatigue in both the individual (f^2 = .59) and team (f^2 = .39) context conditions. However, Extraversion in Step 2 did not add additional variance beyond that predicted by pre-task fatigue measurements in the individual condition. Hypothesis 1 was not supported. For the individual session, final fatigue measurements are related to starting position, not individual differences in extraversion. Results of the second regression analysis show a significant relationship between extraversion and post-task fatigue in the team context, supporting Hypothesis 2 (f^2 =.06). In the team session, starting position accounts for less variance overall than in the individual session, and extraversion accounts for incremental variance.

Table 8
Hierarchical regressions predicting post-task fatigue

	Individual Context		Team Context	
Predictors	Step 1	Step 2	Step 1	Step 2
Pre-task Fatigue	.61**	.59**	.52**	.51**
Extraversion		-.12		-.20*
R^2	.37	.38	.28	.31
ΔR^2		.01		.04*

* = $p < .05$; ** = $p < .01$; $df1 = 1$, $df2 = 89$;

Multilevel Results

Hypotheses 3 through 5, pertaining to the effects of extraversion and context condition over time-on-task were evaluated using multilevel analyses. Table 9 summarizes the results of these analyses. In the first column are the predictor variables and their respective gamma coefficients. The second column lists the unstandardized *b* coefficients. The third column is the standard error associated with each estimate. The fourth column lists *t*-values, indicating the significance for each predictor. Absolute values greater than 1.96 are statistically significant at the .05 level or smaller. The lower portion of the table describes the variance components for the error terms at each level. The intraclass correlation coefficient for the random-intercepts model showed that 51% of variance existed within subjects, while 49% occurred between subjects.

As can be seen by the values in the third column, the first three steps entered in the model are significant predictors of fatigue. In support of Hypothesis 3, there was a main effect of time, such that each 44-minute interval of time-on-task was associated with an increase in subjective fatigue ($b = 3.04$, $t = 12.76$). In support of Hypothesis 4,

there was also a significant time x condition interaction (b = -1.21, t = -6.75). Participants grew fatigued more slowly in the team context relative to the individual context. In addition, a significant main effect was observed for Extraversion in both conditions (b = -.44, t = -2.24). Overall, participants higher in extraversion reported significantly less fatigue over time-on-task than those lower in extraversion (b = -.44, t = -2.24). Between contexts, however, higher extraversion scores did not predict significant changes in the within-person fatigue slope (b = -.08, t = -.36). Contrary to Hypothesis 5, the three-way interaction effect between Time, Extraversion, and Context was not significant. The variance accounted for by the full model was compared to the null model with only random intercepts, showing a 26% improvement in variance accounted for ($\Delta R^2_{(Level\text{-}3)}$ = .02; $\Delta R^2_{(Level\text{-}1)}$ = .24; Note: Reliable effect size estimators have not been developed for HLM analyses. For a discussion of the challenges in estimating effect sizes, see Roberts & Monaco, 2006). In contrast, the results suggest that the fatigue-reducing properties of the team performance context did not depend on individual differences in extraversion.

Table 9
HLM estimates for impact of context and extraversion on rate of fatigue over time-on-task

Fixed Effects	Coefficient	SE	*t*
(Intercept), γ_{000}	24.80	1.00	24.81**
Time γ_{100}	3.04	.24	12.76**
Time x Context, γ_{110}	-1.21	.25	-6.75**
Time x Extraversion, γ_{101}	-0.44	.18	-2.24*
Time x Context x Extraversion, γ_{111}	-0.08	.25	-.36 (*ns*)

Random Effects	Variance
Intercept (Participant)	58.49
Residual (Time)	44.60

Note: HLM = Hierarchical linear modeling; Time = 4 x 44 minute increments; * = $p < .05$; ** = $p < .01$.

Neuroticism has been shown to predict pre-task fatigue (Ackerman & Kanfer, 2009). There was concern that changes in fatigue levels over time might be accounted for by neuroticism rather than fatigue. To address this concern, a second multilevel analysis was conducted to account for neuroticism's impact on changes in fatigue over time. If the interaction between time and neuroticism was significant, this would support a relationship to change in fatigue over time. If, however, this interaction was not significant after accounting for a main effect of neuroticism overall, it would suggest that neuroticism is related to starting position but not change in fatigue over time. The second multilevel analysis, presented in Table 10, showed that neuroticism was related to starting position ($b = 2.57$, $t = 2.68$, $p < .05$), but not to rate of fatigue ($b = .25$, $t = 1.12$, *ns*). As extraversion was not significantly correlated with pre-task fatigue in either session, these results validate the preliminary assumptions that neuroticism would be related to starting position, but change in fatigue over time-on-task would occur as a function of extraversion.

Table 10
HLM estimates for impact of context and neuroticism on rate of fatigue over time-on-task

Fixed Effects	Coefficient	SE	*t*
(Intercept), γ_{000}	24.80	.96	25.90**
Time γ_{100}	3.03	.24	12.71**
Time x Context, γ_{110}	-1.21	.18	-6.74**
Neuroticism, γ_{001}	2.57	.18	2.68*
Time x Neuroticism, γ_{101}	0.25	.22	1.12

Random Effects	Variance
Intercept (Participant)	50.75
Residual (Time)	44.77

Note: HLM = Hierarchical linear modeling; Time = 4 x 44 minute increments; * = $p < .05$; ** = $p < .01$.

Behavioral preferences and fatigue

The effect of preference for environmental stimulation and peer interaction on fatigue was tested with hierarchical regression analyses for each context. The results of these analyses are presented in Table 11. Neither variable significantly predicted post-task fatigue, after accounting for the effects of pre-task fatigue. Hypotheses 6 and 7 are therefore not supported, suggesting that behavioral preferences did not play a deciding role in fatigue within the constrained context of the laboratory study.

Table 11
Hierarchical regressions predicting post-task fatigue

	Individual Context			Team Context		
Predictors	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Pre-task Fatigue	.61**	.59**	.59**	.53**	.50**	.51**
Environ. Stimulation.		.10	.08		.08	.06
Peer Interaction			.07			.05
R^2	.37	.38	.36	.28	.28	.26
ΔR^2		.01	.00		.01	.00

** = $p < .01$; $df1 = 1$, $df2 = 89$; Regression coefficients are standardized

Relationship between fatigue and subjective performance

Results of an hierarchical regression analysis to evaluate the potential moderating role of achievement motivation in the fatigue-subjective performance relationship (Hypothesis 8) are presented in Table 12. As shown in Table 12, individual differences in achievement motivation predicted post-task fatigue, but there was no significant interaction effect. Hypothesis 8 was therefore not supported. That is, fatigue did not change the relationship between achievement motivation and subjective assessment of performance on the financial planning scenarios.

Table 12

Hierarchical regressions predicting subjective performance

	Individual Context			Team Context		
Predictors	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Ach. Mot.	.21*	.12	.44	.25*	.19*	-.09
Fatigue		-.37**	.34		-.38**	-.95
Ach. Mot x Fat.			-.71			.85
R^2	.04	.17	.18	.06	.21	.21
ΔR^2		.13	.01		.14	.01

* = $p < .05$; ** = $p < .01$; $df1 = 1$, $df2 = 89$; Fatigue = Post-task fatigue; Regression coefficients are standardized.

CHAPTER 4

DISCUSSION

This study provides new insights into the proverb "Many hands make light the work" (Heywood, 1546). Although the proverb is typically interpreted and studied in terms of the division of labor, there is also a tacit popular belief that working in a team has important psychological benefits, including the mitigation of fatigue that typically increases with greater time-on-task. To date, however, only one study has examined teamwork as a context which has an impact on fatigue effects (Whitmore et al., 2008). The present research extends these findings by demonstrating the importance of context and person-task interactions in the assessment of fatigue. Building on theories of fatigue and personality, I used a multilevel, counterbalanced design and high-fidelity task to examine the differential impact of individual and team performance context on feelings of fatigue over hours of time-on-task. I found that working in teams (compared to working alone) yielded a quantifiable psychological benefit that attenuated fatigue early in the work session. This benefit was maintained, resulting in a lower comparative net increase in work-related fatigue over time-on-task. Furthermore, the advantage bestowed by the team context was unconditional. Introverts and extraverts benefited equally from performing in a team, suggesting that the positive effects of teamwork at the individual level did not depend on team member characteristics. The mechanisms through which the team context attenuated fatigue are not immediately clear. The effect may have occurred as a result of social factors which impacted fatigue directly such as improved mood, arousal, or change in motivational states. Alternately, or in conjunction, the team task

condition may have changed task demands by reducing effort, workload, or demands on attention.

The results obtained also bear indirectly upon Eysenck's (1973) baseline arousal hypothesis, particularly with respect to the finding of a significant main effect for extraversion on fatigue over time-on-task in both performance contexts. Eysenck's hypothesis predicts that context stimulation (associated in this study with the team condition) would benefit extraverts, but over-arouse introverts. However, laboratory studies to support Eysenck's arousal hypothesis on the effects of extraversion on performance in low and high stimulation paradigms often use tasks designed to induce fatigue-related decrements among extraverts, including, for example,reaction-time tasks (e.g., Beauducel et al., 2007; Linden et al., 2007; Matthews et al., 1990; Smulders & Meijer, 2007) or vigilance tasks (e.g., Matthews & Desmond, 1998; Schmidt et al., 2004; Smillie, Yeo, & Lang, 2009). Such tasks require high demands on attention and provide little stimulation, providing poor person-task fit for those requiring greater levels of stimulation (i.e., extraverts).

In contrast, I found no significant difference in the mitigating effect of extraversion on fatigue by performance context. Neither did I find a relationship between extraversion and pre-task fatigue measurements. Since participants were aware of which context they would be performing before fatigue measurements were taken, it is unlikely that extraverts benefited from more positive expectancy prior to engaging in the task. In light of these results, I offer three plausible interpretations for my findings. First, it may be that the benefits of extraversion on subjective fatigue over time-on-task are specific to task properties and their associated sources of arousal (i.e., task-specific arousal vs.

content-related arousal) (Lieberman and Rosenthal, 2001; Furnham & Strabac, 2002). This explanation suggests that task-related stimulation is processed differently by introverts and extraverts, while context-related stimulation is not. Accordingly, variance in subjective fatigue can be attributed to changes in arousal, but the sources of stimulation generating arousal can be partitioned into context-specific arousal and task-specific arousal, with extraverts experiencing greater task-specific arousal in both performance conditions. The finding that extraverts did not show evidence of anticipatory arousal reinforces this notion that benefits emerge solely through task performance.

A second explanation for the mitigating effect of extraversion on subjective fatigue in both conditions derives from consideration that an alternative mechanism may be involved (Lucas, Diener, Grob, Suh, & Shao, 2000). This explanation challenges the assumption that individual differences in extraversion have their effects on fatigue and performance solely through arousal. Alternative explanations, such as that offered by Lucas, Diener, Grob, Suh, and Shao (2000), suggest that the effects of person and situation on fatigue may occur through two separate pathways; task enjoyment and arousal. Consistent with this formulation, it may be that the main effect for extraversion observed in this study stems from the positive association between extraversion and positive affect, whereas the impact of performance context stems from arousal. According to this explanation, positive affect, not arousal, mediated task effects on fatigue, such that extraverts enjoyed the task more than introverts, and consequently exerted fewer self-regulatory resources to maintain task performance.

Indirect evidence for the beneficial impact of extraversion in both individual and team performance conditions is provided by Sterns, Alexander, Barrett, and Dambrot

(1983) and De Vries and Van Heck (2002). Sterns et al. (1983) suggested that goal-related activation increases task-specific arousal, and found that extraverts preferred jobs with higher levels of cognitive task demands, pace of task demands, cognitive closure, extrinsic rewards and intrinsic rewards. De Vries and Van Heck (2002), also showed a negative relationship between extraversion and occupational fatigue. Accordingly, the relatively complex task demands of the financial planning task used in this study may thus have aroused extraverts more than introverts. As a result, extraverts may have received a unique, context-independent benefit from task engagement.

A third possible explanation for the impact of extraversion on fatigue pertains to the effect of this trait on processing of task demands (Linden, Zurron, & Diaz, 2007). Linden et al. (2007) suggested that introverts and extraverts may use different processing strategies in response to low levels of stimulation. For example, it may be that extraversion is related to self-regulatory processing strategies, such that extraverts are more likely to perform a task in such a way as to make it more interesting, but introverts will not (or cannot) do so. The additive effect of context- and task-related arousal suggest that all participants benefited from increased stimulation in the team task, but only extraverts sought out additional task-related stimulation. This effect is consistent with Eysenck's (1973) proposal that extraverts have a higher "ceiling" for the benefits of arousal before TMI occurs.

Study Limitations

Consistent with research in the cognitive fatigue domain, time-on-task was used as the common metric by which to equate effort allocations in the individual and team performance conditions. Unfortunately, however, this metric does not control for mental

workload, both within and across sessions. Multi-format research designs that evaluate physiological indices of arousal, mental workload, and content analysis of team member verbalizations and activities are needed to further pinpoint the processes by which teams mitigate fatigue in sustained performance environments. In a related vein, the evaluation of fatigue in the team context introduces two potential confounds. In contrast to the individual performance condition, the team context provided informal opportunities for micro-periods of rest during discussion that might have reduced fatigue without impeding task performance. The second issue in team dynamics was the distribution of workload across team members. Informal observations of team performances suggested that one team-member within a group was the most vocal. Future research will need to more formally evaluate team dynamics to determine the relationship between fatigue and member role. Finally, although the focus of this study was on fatigue, rather than performance, the lack of performance measures in this study did not allow for assessment of fatigue consequences.

Implications

The findings of this study have theoretical and practical implications. Fatigue researchers have long recognized the importance of subjective fatigue as a precursor and potential determinant of performance declines in tasks performed for sustained periods of time (see Ackerman, 2011). To date, however, most investigations of personality and environmental influences on subjective fatigue over time-on-task have been conducted using laboratory tasks that bear little resemblance to the post-industrial work setting. The use of a financial planning problem task demands the use of cognitive abilities (e.g., complex reasoning) that have higher external validity to modern knowledge work than

previous paradigms like driving simulations or vigilance tasks. The findings using this task paradigm did not conform to prior laboratory research on the effects of extraversion on fatigue over time-on-task, but are consistent with recent suggestions for the multiple pathways by which extraversion may affect fatigue. Overall, the financial planning task paradigm represents an incremental increase in generalizability over passive sustained attention tasks.

Between 1994 and 2000, the Bureau of Labor Statistics estimated that the number of Americans working forty-nine hours per week or more increased by 1.8 million (BLS; 2000). Human resource managers have become increasingly interested in the person and job design determinants of subjective fatigue, and the relationship between fatigue and outcomes such as work well-being (Gander, Hartley, Powell, Cabon, Hitchcock, Mills & Popkin, 2011), work withdrawal (Houkes, Janssen, de Jonge & Bakker, 2003), and job performance (Friesen, Vidyarthi, Baron & Katz, 2008). Future scientists and practitioners may expand the current findings to examine the potential role that work design (teams) and self-regulatory training to combat fatigue may have in mitigating fatigue and downstream fatigue-related errors and performance decrements.

Conclusions

Although fatigue associated with sustained job performance remains a continuing concern in many jobs, there has been a disconnect between advances in experimental fatigue research and work psychology. Cognitive and personality researchers have focused on the individual differences associated with fatigue accumulation, while occupational researchers have examined the job design elements and distal outcomes associated with fatigue. This study sought to integrate these literatures by investigating

the effects of work context and extraversion on fatigue over time-on-task. Using a complex, problem-solving task paradigm, I found significant main effects for performance context and extraversion on fatigue over time. Both the team context and extraversion attenuated fatigue associated with length of task performance but their effects operated independently. The more pronounced benefit of the team context, coupled with the lack of a significant interaction effect, indicates that performance context was more important in this study than individual differences in attenuating negative affective reactions to mental work. Furthermore, the experiential benefit one receives from team task performance does not depend on individual differences in personality or behavioral preferences.

The beneficial effects of these variables on fatigue mitigation suggests further attention is needed for understanding the affective mechanisms by which the team context may lessen subjective fatigue over time. Findings obtained for the protective role of extraversion on fatigue over time is inconsistent with many prior laboratory findings on the extraversion-fatigue relationship, and suggests that the impact of extraversion on fatigue over time may occur through multiple pathways, beyond that of arousal. While over a century of fatigue research has found only a tenuous relationship between subjective fatigue and performance decrement, emerging research on the links between subjective fatigue and burnout reflect a growing area of overlap between fatigue research and practice. The beneficial impact of a team performance context on fatigue over time-on-task demonstrates the potential value of a closer integration of fatigue and organizational research for advancing basic and applied psychology concerns.

APPENDIX A

FINANCIAL PLANNING INSTRUCTIONS: INDIVIDUAL

CONTEXT

Over the course of today's session you will complete a series of financial planning problems. We are interested in learning more about how college students without formal training in accounting can solve these types of problems.

Answering

- You will work at your own pace for the duration of the session.
- You will be provided with a scenario and relevant financial information.
- You are to solve the problem using the information provided to you and your judgment. Each problem can be solved satisfactorily in more than one way, but make your answer as realistic as possible.
- Some problems may not provide information you feel is necessary to provide a satisfactory answer. In these cases, provide an assumption that you feel is realistic and necessary to the solution. Be sure to write this assumption in your answer.
- Blank space on the question sheet should be used as scratch paper to show any calculations that may be required.
- If you are confused about a term, please refer to the glossary before asking the experimenter a question.
- Based on our past experience with these kinds of problems, we have found that it is best when you complete the problem in three stages. We suggest you do them in the following order:
    - First, list the factors that could potentially impact your suggestion.
    - Second, devise a math-based solution to the problem by calculating the prospective outcomes of several alternative recommendations, based upon the factors listed in step one.
    - Third, provide a written summary of your recommendation on the answer sheet following each problem, citing the calculations previously described.

You will be given a break every 45 minutes. You must work on the problems in the order that they are given, not moving on to the next one until you have completed the previous problem. Complete as many as you can, but it is better to complete some of the problems thoroughly than to complete all of the problems poorly.

Your answers will be graded according to the thoroughness and complexity of your answers.

Do not turn the page until instructed to do so by the experimenter

APPENDIX B

FINANCIAL PLANNING INSTRUCTIONS: TEAM CONTEXT

Over the course of today's session you will complete a series of financial planning problems. We are interested in learning more about how college students without formal training in accounting can solve these types of problems. *The purpose of the exercise is to work collaboratively in order to make the best recommendation possible. You are encouraged to communicate, brainstorm, and divide work among your teammates in order to come up with a thorough and accurate response. Any calculations delegated to a teammate must be shown on that team member's scratch paper.*

Answering

- You will be provided with a scenario and relevant financial information.
- You are to solve the problem using the information provided to you and your judgment. Each problem can be solved satisfactorily in more than one way, but make your answer as realistic as possible.
- Some problems may not provide information you feel is necessary to provide a satisfactory answer. In these cases, provide an assumption that you feel is realistic and necessary to the solution. Be sure to write this assumption in your answer.
- Blank space on the question sheet should be used as scratch paper to show any calculations that may be required.
- It is best when you complete the problem in three stages.
    - First, list the factors that could potentially impact your suggestion.
    - Second, devise a math-based solution to the problem by calculating the prospective outcomes of several alternative recommendations, based upon the factors listed in step one.
    - Third, provide a written summary of your recommendation on the answer sheet following each problem, citing the calculations previously described.
- *Please have one person write your answer, along with a short justification, on the answer sheet provided.*
- Continue on to the next problem only when you are totally satisfied with your answer.
- *When moving to the next question, please pass the answer sheet to the next person in the team so as to balance the workload among teammates.*

You do not have to complete all of the scenarios. However, your answers will be graded according to the thoroughness and complexity of your answers, so please ensure that you are totally satisfied with your answer before moving to the next question.

Please do not turn the page until instructed to do so by the experimenter

APPENDIX C

FINANCIAL PLANNING QUESTIONS

PROBLEM 1

Betty and David haven't been getting along with one another for several years, but decided to stay together for the sake of their daughter, Angela. However, Angela left for college this year (at a local public university) and they see no possible way to work out their problems. They have agreed to attempt a fair divorce settlement after 19 years of marriage. Betty and David own a home together worth $190,000. They bought the home 15 years ago for $100,000 and have a fair amount of equity built up in the house. Their daughter Angela lives in the dorm at college. David works as a contractor making $80,000 annually. For a while, Betty stayed at home to take care of their child, but began working part-time as a real estate agent three years ago. She has made an average of $35,000/year over the past three years. Betty's salary has mainly been used for investments and payment of their child's college tuition. With this money, Betty and David have a mutual fund worth $20,000 that they planned to use to pay for Angela's tuition. David has an IRA setup for retirement which is worth $120,000 that he started after he and Betty were married. David also carries life and health insurance for his family through his employer. Betty does not know much about finances and is concerned about the impact of the divorce on her financial well-being. She realizes that she needs to contact a lawyer, but wants to be educated about her financial situation before she meets with a lawyer.

Considering all aspects of their financial situation, what should Betty expect to receive as part of the divorce settlement? In your response, please list some options that would address the question. Provide a discussion of the advantages and disadvantages to the options. Also, indicate the best solution for the scenario, given these considerations.

Betty and David's information

Names	Betty, David, and Angela Adams
Occupations	Contractor (David), Real Estate Agent (Betty)
Ages	Betty (45), David (43), Angela (18)
Salary	$115,000/annual (Betty = $35,000; David = $80,000)
Home	$190,000
Mortgage	$43,931 after 15 years at 8% interest. $734/month
Retirement accounts, pensions	$120,000 in IRA for David
Investments	$20,000 in mutual fund for Angela's education
Personal property	$10,000 in jewelry
Car payments	NA
Tuition payments	NA
Credit card balances	NA
Loans	NA

PROBLEM 2

Carter is 46 years old and recently lost his job as an advertising manager along with its $65,000/year salary. Carter's wife, Rose stays at home with their two kids. They purchased their home 9 years ago and are currently paying $1079.19 monthly for their home at an interest rate of 6% (the current rate). They also have about $3000 in credit card debt, at an average interest rate of 15%. Carter had been working at the same company for the past 10 years. He has a 401(k) with his former employer worth $50,000 that he was planning to use for retirement. He also has a severance package from his former employer, which includes two weeks of pay per year of service (20 weeks of full pay). Carter is concerned about finding a new job before his severance package runs out and how he might continue to support his family if he is not able to find a new job, or finds a new job that pays significantly less than his current salary. He is also concerned about how he might continue to provide the benefits he received at work (i.e., life and health insurance) for his family now that he is no longer working.

> What would you recommend Carter do to minimize the financial impact of his job loss on his family? In your response, please list some options that would address the question. Provide a discussion of the advantages and disadvantages to the options. Also, indicate the best solution for the scenario, given these considerations.

Carter and Rose's information

Name	Carter, Rose, Jada, and Dante Reese
Occupation	Advertising manager
Ages	Carter (46), Rose (40), Jada (5), Dante (2)
Salary	$65,000
Home	$180,000
Mortgage	$123,729 after 9 years at 6% interest. $1079.19/month
Retirement accounts, pensions	$50,000 in 401(k)
Investments	NA
Personal property	NA
Car payments	$180/month
Tuition payments	NA
Credit card balances	$3000 at 15%
Loans	NA

PROBLEM 3

Matthew is a 30 year old manager at a large corporation and earns $60,000 annually. He is married to Debbie, who is 29 and stays at home taking care of their two children (ages 2 and 4). Matthew has decided to purchase life insurance to protect his family financially if he or his wife dies. Money is tight right now, but he hopes to move up in the company in a few years. He has a 401(k) retirement plan worth $20,000 and some investments in mutual funds with a well-known company worth $5,000.

What would you recommend for a long-term plan for life insurance for Matthew and Debbie? In your response, please list some options that would address the question. Provide a discussion of the advantages and disadvantages to the options. Also, indicate the best solution for the scenario, given these considerations.

Matthew and Debbie's information

Names	Matthew and Debbie Zola. Children are George (4 years), Gracie (2 years)
Occupations	Manager (Matthew), Stay at home mom (Debbie)
Ages	30 (Matthew), 29 (Debbie)
Salary	$60,000
Home	$175,000
Mortgage	$139,358 after 5 years at 6% interest ($1049/month)
Retirement accounts, pensions	$23,000 in 401(k)
Investments	$5,000 in mutual funds
Personal property	NA
Car payments	$245/month
Tuition payments	NA
Credit card balances	NA
Loans	NA

PROBLEM 4

Kim and Lee have a new baby named Lucy. They have never gone to college and struggle making ends meet. Their dream is to have a child who graduates from college. They have 18 years in which to save. They expect to be able to pay for some of the cost, but are counting on financial aid. They would also like to put aside some money now to accumulate for Lucy's college.

What do you recommend as a good option for Kim and Lee's goal? In your response, please list some options that would address the question. Provide a discussion of the advantages and disadvantages to the options. Also, indicate the best solution for the scenario, given these considerations.

Kim, Lee, and Lucy's information

Names	Kim, Lee, and Lucy Huang
Occupations	Customer service representative at bank (Kim), Pastry chef (Lee)
Ages	27 (Kim), 29 (Lee), 6 months (Lucy)
Salary	$55,000/annually
Home	$80,000
Mortgage	$63,706 after 5 years at 6% interest ; $480/monthly; 10% down payment
Retirement accounts, pensions	$30,000 in retirement accounts
Investments	NA
Personal property	NA
Car payments	$212/month
Tuition payments	NA
Credit card balances	$1,500 at 6%
Loans	NA

PROBLEM 5

Myra is a 30 year old paralegal who has just recently started thinking about retirement. She wants to retire at the age of 62. Right now, Myra makes $50,000 annually. She bought her home 7 years ago for $100,000. She put 10% down on the house and had an original mortgage of $90,000 at a 6% interest rate. Her current house payments are $599 per month. She works for a small company which does not offer retirement plans. During retirement, she will need about 70% of her current income (or $35,000) annually. She estimates that she will receive $14,400/year from social security upon retirement. Myra prefers safe investments; she does not like to take risks with her money. She feels she can put away $250/month to save for retirement.

How would suggest that Myra begin saving for retirement? In your response, please list some options that would address the question. Provide a discussion of the advantages and disadvantages to the options. Also, indicate the best solution for the scenario, given these considerations.

Myra's information

Name	Myra James
Occupation	Paralegal
Age	30
Salary	$50,000/annually
Home	$100,000
Mortgage	$74,511 after 7 years at 6% interest ($599/month)
Retirement accounts, pensions	NA
Investments	NA
Personal property	NA
Car payments	NA
Tuition payments	NA
Credit card balances	$1,000 at 7%
Loans	NA

PROBLEM 6

Victor and Maria have owned their home for five years. They have run up $15,000 in credit card debt (on 6 different credit cards) in buying furniture and appliances. The average interest rate on their six different credit cards is 18%. The cost of their home was originally $180,000, and they put 10% down. The original mortgage of $162,000, with an interest rate of 8%, requires a monthly payment of $1,320. Home mortgage interest rates are now 6%. Victor and Maria plan to live in their house for at least another 5 years unless one of them has a job transfer. They also have 401(k) and 403(b) retirement plans at work totaling $50,000. They are worried about falling behind in paying their bills. They would like to have more money available at the end of each month in order to save to start a family.

How would you advise Victor and Maria to reduce their monthly payments? In your response, please list some options that would address the question. Provide a discussion of the advantages and disadvantages to the options. Also, indicate the best solution for the scenario, given these considerations.

Victor and Maria's information

Names	Victor and Maria Gonzalez
Occupations	Manager at a rental car company (Maria), school teacher (Victor)
Ages	31 (Victor), 30 (Maria)
Salary	Combined is $70,000 per year
Home	$180,000
Mortgage	$144,486 after 5 years at 8% interest ($1,320/month)
Retirement accounts, pensions	$50,000 in retirement accounts
Investments	NA
Personal property	NA
Car payments	NA
Tuition payments	NA
Credit card balances	$15,000 at 18%
Loans	NA

PROBLEM 7

Danny is a 27-year old graduate student making $12,000/year as a Research Assistant. He worked for a time before returning to school and has an IRA worth $14,000 that is yielding an average interest rate of 6% a year. Since being in school, he has accumulated a credit card debt of $14,000, and is paying an interest rate of 18% on unpaid balances. He is falling behind in keeping up with his credit card payments. When he graduates in another year, he would like to buy a home and wants to have a good credit rating in order to qualify for a preferable mortgage rate.
There is a 10% fee for closing the IRA prior to age 65.

A) How would you advise Danny to reach his goal of paying off his credit card debt?
B) Assuming $1,400 in monthly expenses, what steps should he take to reduce his cost of living? Provide reasonable cost reductions and show how these will accumulate over time to yield major savings.

Danny's Information

Name	Danny Smith
Occupation	Graduate Research Assistant
Age	27
Salary	$12,000 per year
Home	NA
Mortgage	NA
Retirement accounts, pensions	$14,000 in an IRA
Investments	NA
Personal property	NA
Car payments	NA
Tuition Payments	NA
Credit card balances	$14,000 at 18%
Loans	NA

PROBLEM 8

Louise and Bob are in their sixties and received a call from their insurance agent about buying long term care insurance. They have heard that people over 65 have a 43% chance of going into a nursing home at some time in their lives. At their age and health status, which has recently changed due to Bob's heart condition, they learned that their premiums would cost about $4,000 per year for both of them ($2,500 for Bob and $1,500 for Louise). However costs for nursing homes in their city can reach an average of $45,000 to $55,000 per year. And their agent told them that about 20% of men and 40% of women live in a nursing home from 3 months to a year, while 10% of men and 5% of women live in a nursing home fewer than three months.

Louise and Bob are on fixed incomes, and the $4,000 premium would be a stretch for them. They own their own home and have a $25,000 annual income from a pension and Social Security and $15,000 in a savings account. They have no relatives nearby to care for them, but they do have a grandchild in another state they'd like to leave the money to.

What do you recommend they do about purchasing long term care insurance?

Louise and Bob's information

Names	Louise and Bob Wilson
Occupations	Retired
Ages	64 (Bob), 63 (Louise)
Salary	$25,000
Home	Own home worth $120,000
Mortgage	NA
Retirement accounts, pensions	$25,000 per year
Investments	$15,000 in savings
Personal property	NA
Car payments	NA
Tuition payments	NA
Credit card balances	NA
Loans	NA

PROBLEM 9

Terri is a 40 year-old who recently inherited $10,000 from a family member and wants to invest it for maximum returns. Terri is doing pretty well financially. She is single, works full-time in a high-level position, owns her own condo, has no consumer debt, and has an adequate retirement account. She is willing to take a certain amount of risk with the money she inherited.

How should Terri invest her money? She could invest it in stocks, bonds, savings accounts, or mutual funds. Stocks could yield a 10% annual return or a 15% loss. Mutual funds yield a 5% expected return or a 3% loss. Bonds yield a 2% return. A savings account yields 3% at present but has the potential to yield a lower return. What would you recommend as an investment strategy for Terri? What proportion should be invested in each? Calculate a best case and a worst-case scenario for the portfolio you have recommended in two, five, and ten years.

Terri's information

Name	Terri Franklin
Occupation	Director, Market Research
Age	40
Salary	$85,000
Home	$200,000 condo
Mortgage	$157,211 after 7 years at 8% interest $1,521/monthly payment
Retirement accounts, pensions	$120,000 in 401(k)
Investments	NA
Personal property	Jewelry worth $10,000 $10,000 inherited from family member
Car payments	$260/month
Tuition payments	NA
Credit card balances	NA
Loans	NA

PROBLEM 10

Carlos and Isabella have a five-year-old child, Constance, and they live outside the city limits. Rather than have Constance attend the distant county school, they would prefer to send her to private school. The private schools they are looking at cost $15,000 per year, so they would like to have $60,000 saved by Constance's 14th birthday. Additionally, they would like to start saving for her college education. Carlos works as an architect and makes $40,000 a year, while Isabella has a salary of $20,000 as a part-time dental hygienist. Carlos expects a 5% annual increase in salary while Isabella expects a 3% increase. A private college typically runs approximately $120,000 over four years, while a state school costs around $10,000 per year for in-state tuition.

What would you recommend Carlos and Isabella do to ensure they can adequately fund Constance's education?

Carlos and Isabella's information

Names	Carlos and Isabella Martinez
Occupation	Architect, Dental Hygienist
Ages	34 (Carlos), 29 (Isabella)
Salary	$60,000
Home	$100,000
Mortgage	$74,443 after 5 years 6% interest ($480/month)
Retirement accounts, pensions	$40,000 in 401(k)
Investments	NA
Personal property	NA
Car payments	NA
Tuition payments	NA
Credit card balances	NA
Loans	NA

PROBLEM 11

11. Suzy Lee is a 24-year-old, 2nd year graduate student making $1,500 a month as a graduate research assistant. Until know, her parents have supplemented her income by paying certain living expenses. Unfortunately, Suzy's parents just announced that they are getting divorced in six months. Her parents have informed her that once the divorce is finalized, Suzy will be cut off from any financial assistance. Suzy realizes that her current standard of living is unsustainable and that she must cut back on her expenses.

She spends $600/month on gas and insurance for her car, which she owns outright. She owns a condominium worth $200,000, but there is $30k left on the mortgage, with $650/month in fees above the $800/month mortgage she is already paying.

A) What must Suzy do in the next 6 months to achieve financial stability? B) If Suzy follows these measures, how much does she stand to save? Provide itemized savings for each expense. C). Though Suzy has no debt, she currently uses a credit card that charges 12% interest on late payments. If she follows the plan you have devised for her, provide a breakdown of what her expenses might look like in four years, taking into account this high interest rate.

Suzy's Information

Name	Suzy Brenton
Occupation	Graduate Research Assistant
Age	27
Salary	$15,000/year
Home	$200,000, 30K left on mortgage.
Mortgage	$800/month, + $650/month HOA fees
Retirement accounts, pensions	NA
Investments	NA
Personal property	Car worth $25,000
Car payments	$600/month, gas + insurance
Tuition Payments	$1,400/Semester
Credit card balances	$0, 12% interest
Loans	NA
Misc. Expenses	$400/month

PROBLEM 12

12. Steven Yamamoto is a 62-year-old physician. He had planned to retire at age 65, but the recent financial collapse has thrown his retirement plans into turmoil. To maintain his current standard of living, he must have $3 million saved by age 65. His insurance agency has projected that he will live until age 85, and he wants to be able to live comfortably with his wife and to leave money to his two sons. He has 75% of his wealth in mutual funds and 25% in stocks. Economists have given three scenarios for recovery: 1) Stocks increase 7% per year, while funds increase 6%; 2) Stocks increase 12%, funds 8%; 3) Stocks and funds both increase 8%. Given these figures

A). Given these figures, provide three different estimates of Alex's yearly increase in wealth, in dollars. B). When will he be able to retire?

Steven and Maru's Information

Name	Stephen and Maru Yamamoto
Occupation	Graduate Research Assistant
Age	62
Salary	$275,000/year
Home	NA
Mortgage	NA
Retirement accounts, pensions	$1,650,000 in mutual funds, $550,000 in stocks
Investments	NA
Personal property	NA
Car payments	NA
Tuition Payments	NA
Credit card balances	NA
Loans	NA

PROBLEM 13

13. Daniel and Jessica are engaged to be married. Daniel has recently taken a lower-paying job with a government agency that pays $85K/yr, but provides more stability and better hours than his previous one in corporate litigation. Jessica operates her own PR firm and brings in $90k a year. They have both had previous relationships go bad due to money issues and want to avoid that situation this time around. They want advice on combining and dividing their finances in the most equitable and efficient way possible. Neither of them has children and they are open to the idea of tightening their belts financially. Jessica is paying $1,800/month on her one bedroom apartment, while Dan is paying $2,400/month on his more spacious one bedroom. Jessica took out a $20k loan to help start her business and after four years she is down to $10k. Dan, meanwhile, has credit card debt that has lingered after his graduation from law school. He is $12k in debt with 12% fixed APR.

A). Provide a cost breakdown over five years for each apartment, accounting for a 2% annual increase in rent prices. Based upon these projections, which apartment would you recommend they keep? B) They lack the funds to pay down all their debt at once. How would you recommend they plan to pay down their combined debts? C). What would be the amount and timeframe for this? D). How much do they stand to save by paying down their debt over five years, as opposed to ten?

Daniel and Jessica's Information

Name	Daniel D'Souza, Jessica Stein
Occupation	Government regulator, PR consultant
Age	34, 33
Salary	$85K/Year, $90K/Year
Home	NA
Mortgage	$1,800/month, $2,400/month.
Retirement accounts, pensions	NA
Investments	NA
Personal property	NA
Car payments	NA
Tuition Payments	NA
Credit card balances	$12k, with 12% interest
Loans	10%, with 6% interest

PROBLEM 14

14. Arthur and Lena McCormac need financial advice. Lena recently gave birth to their second child. Soon afterward, Arthur was laid off from his sales job. He is trying to find another one but money is tight. He wants to get a clear picture of his financial standing. Help Arthur and Lena figure out how long their savings will last. Optimistically, Arthur thinks he can get a job in 2 months.

A). How will his finances look in 2 months? B). What if finding work takes 8 months? What spending cuts would you recommend he make, and what are the monthly savings he could accumulate by following your recommendation? Given the prospect of a part-time job that pays $150/week, and a 5% raise in Lena's salary in two months time, what is their financial outlook 6 months from now? Specifically, assuming their credit card rate is 12%, what will their savings and debt be at the end of six months?

Arthur and Lena's Information

Name	Arthur and Lena McCormac
Occupation	Unemployed (Kevin); Childcare (Lena)
Age	26, 27
Salary	$12,000 per year (Lena)
Home	NA
Mortgage	$1,000/month in rent
Retirement accounts, pensions	NA
Investments	$6,000 in savings
Personal property	NA
Car payments	$200/month
Tuition Payments	NA
Credit card balances	$1,000 at 16%
Loans	NA

PROBLEM 15

15. Raj and Seema Shah. Raj is an independent IT consultant who works with medium sized companies. He was looking to expand his business and upgrade his insurance. Unfortunately he became seriously ill two months prior to the change-over. At this point his insurance will cover 85% of his healthcare costs. He must pay a $10,000 dollar up front deductible before insurance will activate. He has some money saved up but most of his wealth is tied up in property.

How would you advise Raj and Seema to plan for the future? Assuming a six-month illness during which Raj is unable to work, calculate what his assets will look like in that time, based upon some sort of restructuring.

Raj and Seema's Information

Name	Raj and Seema Shah
Occupation	IT (Raj); Homemaker (Seema)
Age	30, 31
Salary	$56,000 per year
Home	$350,000
Mortgage	$1,400/month in mortgage payments
Retirement accounts, pensions	NA
Investments	$6,000 invested
Personal property	$48,000 (Car, Electronics, etc.)
Car payments	NA
Tuition Payments	NA
Credit card balances	$8,000 at 16%
Loans	NA

PROBLEM 16

16. Dale Gordon has just gotten into a car accident and has been sued by the other driver. The trial isn't for another six months, and the verdict may not be handed down until six months after that. Even still, Dale is concerned the ruling might not be in his favor and he wants to prepare for the worst. He read that a typical injury settlement is about $60,000 but he doesn't have that kind of money right now and doubts it will be covered by insurance.

A) How should Dale prepare for an unfavorable settlement of the lawsuit? What money does he need to have available and how should he go about getting it?
B) Getting settlement money is a costly endeavor. What will Dale's monthly and yearly allocations be for spending, earning, and debt?

Dale Gordon's Information

Name	Dale Gordon
Occupation	Furniture Salesman
Age	29
Salary	$33,000/year
Home	NA
Mortgage	$800/month in rent
Retirement accounts, pensions	NA
Investments	$300 in savings account
Personal property	NA
Car payments	$200/month
Tuition Payments	NA
Credit card balances	$0 at 16%
Loans	NA

PROBLEM 17

17. Eduardo and Nancy Cruz are both forty-five years old and have an unexpected baby on the way. Eduardo already has two younger children in college and the cost of raising another one changes his financial plan considerably. Lizbeth, 20, has a year left at a state school costing $10,000 per year. Jeremiah, his younger child, has just started at a private university and has four years left at $38,000 per year. Eduardo's father left $150,000 in a trust fund for Eduardo's children before he died. $110,000 remains in the fund. Eduardo has saved money for retirement and he is hesitant to dip into that money.

What does Eduardo need to do to ensure he can provide for himself and all three of his children? How much must he set aside for each child, and how does this impact his own wealth?

Eduardo and Nancy's Information

Name	Eduardo and Nancy Cruz
Occupation	Banker (Eduardo); Housewife (Nancy)
Age	45, 45
Salary	$85,000
Home	$250,000
Mortgage	$1,200/month mortgage payments
Retirement accounts, pensions	$75,000
Investments	$6,000 in savings
Personal property	NA
Car payments	$200/month
Tuition Payments	$10,000/year (Lizbeth), $38,000 (Jeremiah)
Credit card balances	$500 at 16%
Loans	NA

PROBLEM 18

18. Matt has just finished graduate school and the loans he took out to put himself through are set to start collecting interest. He has not yet received any job offers and money is extremely tight. He has two credit cards A and B with interest rates of 11% and 16%, respectively. Thanks to the student loans Matt has managed to complete his PhD without accumulating any credit card debt, but this looks to soon change.

A) Develop two scenarios for Matt concerning his potential timetable for employment. What type of debt might Matt incur in each?
B) Matt can either hold out for a job with the best pay, or take the first job offer he gets, even though it might be below his ideal salary. Based upon the scenarios you have composed, which option would you suggest Matt take? Provide an explanation for your decision.

Matt's Information

Name	Matt Tran
Occupation	Unemployed
Age	27
Salary	NA
Home	NA
Mortgage	$800/month in rent
Retirement accounts, pensions	NA
Investments	$2,000 in savings
Personal property	NA
Car payments	$200/month
Tuition Payments	NA
Credit card balances	$0 at 16%, $0 at 11%
Loans	NA

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